

sb c1 } [Please amend claim 10 to read as follows:]

10. (Amended)

A self-sustained pulsating laser diode

according to claim 9, wherein said effective refractive index difference parallel to the layers (Δn) is around 1×10^{-3} .
112

A2
Cmt. [Please amend claim 11 to read as follows:]

11. (Amended)

A self-sustained pulsating laser diode

according to claim 1, wherein said carrier density in said flat part of said second cladding layer having a current blocking structure is less than $3 \times 10^{17} \text{cm}^{-3}$.
112

[Please amend claim 12 to read as follows:]

12. (Amended)

A self-sustained pulsating laser diode

according to claim 2, wherein said carrier density in said flat part of said second cladding layer having a current blocking structure is less than $3 \times 10^{17} \text{cm}^{-3}$.
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REMARKS

Reconsideration of this application based on the foregoing Amendment and the following Remarks is respectfully requested.

35 U.S.C. 112, Second Paragraph

The Examiner has rejected claims 1-12 under 35 U.S.C. 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention.

Specifically, the Examiner rejects claims 1-12 under 35 U.S.C. 112 as being indefinite because in independent claims 1, 2 and 9, two separate cladding layers are both written as "a cladding layer".

In response, the applicants have amended claims 1, 2 and 9 to recite "a first cladding layer" and "a second cladding layer", as suggested by the Examiner.

Also, in response to the Examiner's rejection, claims 1, 2 and 9 have been amended to change "said layer thickness" changed to "a layer thickness", as no antecedent basis is given earlier in the claims.

The Examiner also states it is unclear which cladding layer has the carrier density and current blocking structure.

In response, the applicants call to the Examiner's attention that the specification on page 9, lines 8-10, discloses the following:

"Additionally, the carrier density in the p-AlGaInP cladding layer flat part 105 is at least at least $1 \times 10^{17} \text{ cm}^{-3}$ and no greater than $5 \times 10^{17} \text{ cm}^{-3}$, for example $3 \times 10^{17} \text{ cm}^{-3}$."

In Fig. 1, component 105 is disclosed as a second cladding layer having a flat part positioned above a first cladding layer, or p-AlGaInP layer, 103. In view of the foregoing, the applicants have amended claims 1, 2 and 9 to recite "a first cladding layer of a first conductivity type;" and "a second cladding layer of a second conductivity type each being arranged on a semiconductor substrate of the first conductivity type, ..". The applicants have also amended claims 11 and 12 to

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recite "said second cladding layer", for the same reasons to eliminate any potential lack of clarity.

Last, the Examiner states it is unclear which layer has the parallel effective refractive index.

In response, the applicants note that the specification, page 12, lines 4-6, disclose the following.

"Regarding the refractive index difference parallel to the layers, inside and outside the stripe (Δn) as used in the present invention,..."

Therefore, the applicants have amended claims 2 and 9 to recite "an effective refractive index difference parallel to the layers being at least..." The applicants have also amended claims 3, 4 and 10 to provide proper antecedent basis by reciting "effective refractive index difference parallel to the layers..." The applicants have also amended claims 3 and 4 to replace the limitation "either or both GaInP and AlGaInP" with "at least one of GaInP and AlGaInP" to improve claim form.

Other minor editorial changes have been made to claims 1-4, 9 and 11-12 to improve claim form. No new matter has been added to any of the amended claims 1-4 and 9-12 by the foregoing amendments.

35 U.S.C. 102(b) Rejections: Claims 1-4 and 9-12

The Examiner has rejected claims 1-4 and 9-12 under 35 U.S.C. 102(b) as being anticipated by Kidoguchi et al (US 5,502,739 – filed March 1, 1995 – issued March 26, 1996).

The Examiner asserts that Kidoguchi, Fig. 21A, illustrates AlGaInP cladding layers 202 and 205, a multiple quantum well 204 having five well layers 211 of GaInP shown in Fig. 21B and a current block layer 207.

The applicants note specifically that Kidoguchi et al, column 18, Example 5, discloses with respect to Fig. 21 A a first n-AlGaInP cladding layer 202, *an AlGaInP optical guide layer 203*, a multi-quantum well layer 204, and *a pair of AlGaInP optical guide layers 203* formed on an n-GaAs substrate 201, and a second AlGaInP cladding layer 205 formed in the form of stripes embedded in a current block layer 207. Furthermore, *the multi-quantum well layer 204 has barrier layers 212 and well layer 211 alternating on each other and out-barrier layers 212a formed outside these layers.*

The applicants respectfully maintain that under 35 U.S.C. §102, anticipation of a claim requires that the prior art reference disclose each and every element of the claim to which it is applied.

The specification, page 6, lines 16-23, discloses the following:

“A feature of the laser diode according to the present invention is that it satisfies all of the conditions of (1) having five or more well layers but no greater than 10 well layers of the MQW (*multiple quantum well*) active

layer, (2) having a p-AlGaInP cladding layer flat part with a layer thickness of at least 300 nm and no greater than 500 nm, and (3) having a p-AlGaInP cladding layer flat part with a carrier density of at least $1 \times 10^{17} \text{cm}^{-3}$ and no greater than $5 \times 10^{17} \text{cm}^{-3}$.”

As disclosed in the specification, on page 9, line 29, to page 10, line 29, maintaining the carrier density no greater than $5 \times 10^{17} \text{cm}^{-3}$ makes it possible to make the current distribution small in comparison with the light distribution in the horizontal direction, thereby enabling strong self-sustained pulsating operation, and maintaining stable self-sustained pulsating operation even at a high temperature. When the layer thickness of the flat part of the p-AlGaInP cladding layer is greater than 500 nm, there is a noticeable current broadening. Causing the p-AlGaInP cladding layer flat part carrier density to be less than $1 \times 10^{17} \text{cm}^{-3}$ results in an increase in carrier overflow from the active layer into the cladding layer, making high-temperature operation as a normal laser difficult, so that it isn't possible to maintain self-sustained pulsating operation at a high temperature.

It is also disclosed in the specification, page 9, lines 24-28, that in the construction of this embodiment, the value of Δn is approximately 1×10^{-3} and, compared with the construction of the past (approximately 7×10^{-3}), it is possible to achieve a sufficiently small value within a range that does not cause a worsening of laser characteristics.

For the self-sustained pulsating laser diode to actuate at high temperature, it is very important to broaden the light distribution in the horizontal direction and to suppress broadening of current in the horizontal direction.

If the effective refractive index difference parallel to the layers (Δn) is made small, the light distribution in the horizontal direction is broadened. At the same time, when the carrier density of a flat part of the cladding layer is reduced, i.e., the electric resistance of a flat part of the cladding layer is increased, it becomes possible to suppress broadening of the current in the horizontal direction.

However, if the effective refractive index difference parallel to the layers (Δn) is reduced too much, mode stabilization in the horizontal direction deteriorates. Correspondingly, if the carrier density is reduced too much, operation at high temperature becomes difficult due to carrier overflow from the active layer into the cladding layer.

From this perspective, the applicants have determined a suitable range for the effective refractive index difference (Δn) and the carrier density.

It should also be noted that the effective refractive index difference Δn strongly depends upon the number of quantum wells and the layer thickness of the flat part of the cladding. When the number of quantum wells is increased, the effective refractive index difference Δn decreases, but even when the thickness of the flat part of the cladding layer is increased, the effective refractive index difference is reduced also.

Therefore, in the present invention recited by claims 1, 2 and 9, the value of the effective refractive index difference and the value of the carrier density of the flat part of the cladding layer are numerically restricted and, simultaneously, the number of wells and the thickness of the flat part of the cladding layer are also

numerically restricted as a specific configuration which can realize the aforementioned effective refractive index difference Δn .

Furthermore, it should be noted that when the number of wells is increased excessively, the operating current will be excessively increased also.

In summary, in the present invention recited by claims 1, 2 and 9, due to the aforementioned restrictions, to realize a desired effective refractive index difference, not only the number of wells but also the thickness of the flat part of the cladding layer is adjusted.

With respect specifically to claim 1, the applicants respectfully maintain that Kidoguchi et al does not disclose, teach or suggest a first cladding layer and second cladding layer; a multi-quantum well active layer, the number of said quantum wells being at least 5 and no greater than 10; and a layer thickness of a flat part of said second cladding layer having a current blocking structure being at least 300nm and no greater than 500nm; and a carrier density in said flat part of said second cladding layer having a current blocking structure being at least $1 \times 10^{17} \text{cm}^{-3}$ and no greater than $5 \times 10^{17} \text{cm}^{-3}$, as recited by claim 1.

Therefore, the present invention recited by claim 1 enables sufficiently strong self-sustained pulsating laser diode operation, and it is possible to achieve this at high temperatures, which is not disclosed by the structure of Kidoguchi et al of Fig. 21A and 21B.

Consequently, in view of the supplementary remarks and the foregoing specific remarks, claim 1 patentably distinguishes over Kidoguchi et al.

With respect specifically to claim 2, the applicants respectfully maintain that Kidoguchi does not disclose, teach or suggest a first and second layer with an effective refractive index parallel to the layers being at least 7×10^{-4} and no greater than 3×10^{-3} , and a carrier density in a flat part of said second cladding layer having a current blocking structure being at least $1 \times 10^{17} \text{ cm}^{-3}$ and no greater than $5 \times 10^{17} \text{ cm}^{-3}$, as recited by claim 2.

Therefore, the present invention recited by claim 2 enables sufficiently strong self-sustained pulsating laser diode operation, and it is possible to achieve this at high temperatures, which is not disclosed by the structure of Kidoguchi et al of Fig. 21A and 21B. Kidoguchi et al does not disclose teach or suggest an effective refractive index parallel to the layers (Δn) being at least 7×10^{-4} and no greater than 3×10^{-3} , as recited by claim 2, which prevents deterioration in the laser characteristics.

Consequently, in view of the supplementary remarks and the foregoing specific remarks, claim 2 patentably distinguishes over Kidoguchi et al.

Similarly, with respect specifically to claim 9, the applicants respectfully maintain that Kidoguchi et al does not disclose, teach or suggest a first and second layer, a multi—quantum well active layer; the number of said quantum wells being at least 5; *and a layer thickness of a flat part of said second cladding layer having a current blocking structure being at least 300nm; and an effective refractive index difference parallel to the layers (Δn) being at least 7×10^{-4} and no greater than*

Therefore, the present invention recited by claim 9 enables sufficiently strong self-sustained pulsating laser diode operation, and it is possible to achieve this at high temperatures, which is not disclosed by the structure of Kidoguchi et al of Fig. 21A and 21B. In particular, Kidoguchi et al does not disclose teach or suggest an effective refractive index parallel to the layers being at least 7×10^{-4} and no greater than 3×10^{-3} , as recited by claim 9, which prevents deterioration in the laser characteristics. Consequently, in view of the supplementary remarks and the foregoing specific remarks, claim 9 patentably distinguishes over Kidoguchi et al.

In view of the foregoing arguments with respect to claims 1, 2 and 9, claims 3-4 and 10-12 also patentably distinguish over Kidoguchi et al.

35 U.S.C. 103(a) Rejections: Claims 5-8

The Examiner has rejected claims 5-8 under 35 U.S.C. 103(a) as being unpatentable over Kidoguchi et al.

The Examiner asserts that Fig. 21A and 21B of Kidoguchi et al disclose all of the limitations of claims 5-8, of a self-sustained pulsating laser diode of claims 1-4, respectively, except wherein the (001) plane of the semiconductor substrate is misoriented by 5 degrees or more toward the [110] direction, and wherein the multi-quantum active layer consists of compressively strained wells.

The Examiner asserts that Kidoguchi et al does not disclose the misorientation, but that it would have been an obvious matter of design choice to provide misorientation in the laser system since misorientation does not solve any

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stated problem because the applicant has clearly disclosed and implied on page 12, lines 25-28, that the device can solve the stated problems regardless of the orientation.

In response, the applicants respectfully maintain that in view of the foregoing arguments with respect to claims 1-4 over Kidoguchi et al, claims 5-8 patentably distinguish over Kidoguchi et al.

The foregoing Amendment and Remarks establish the patentable nature of all of the claims in the application, i.e., claims 1-12. No new matter has been added, wherefore, early and favorable reconsideration and issuance of a Notice of Allowance are respectfully requested.

Attached hereto is a marked-up version of the changes made to the claims by the current amendment. The attached page is captioned **"Version with markings to show changes made."**

Respectfully submitted,



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Enclosures: Versions With Markings
To Show Changes Made



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VERSION WITH MARKINGS TO SHOW CHANGES MADE

In the Claims:

Claim 1 has been amended as follows:

1. (Amended) A self-sustained pulsating laser diode [which]
having a double-heterostructure [minimally] comprising:
a first cladding layer of a first conductivity type;
a multi-quantum well active layer; and
a second cladding layer of a second conductivity type each being arranged on
a semiconductor substrate of the first conductivity type, [wherein] the number of
said quantum wells being at least 5 and no greater than 10; and [said] a layer
thickness of a flat part of said second cladding layer having a current blocking
structure [is] being at least 300nm and no greater than 500nm; and [further
wherein] a carrier density in said flat part of [the] said second cladding layer having
a current blocking structure [is] being at least $1 \times 10^{17} \text{cm}^{-3}$ and no greater than
 $5 \times 10^{17} \text{cm}^{-3}$.

Claim 2 has been amended as follows:

2. (Amended) A self-sustained pulsating laser diode [which]
having
a double-heterostructure [minimally] comprising:
a first cladding layer of a first conductivity type;
a multi-quantum well active layer; and
a second cladding layer of a second conductivity type each being arranged on
a semiconductor substrate of the first conductivity type, [wherein]
an effective refractive index difference parallel to the [layer is] layers (Δn) being at

least 7×10^{-4} and no greater than 3×10^{-3} , and [further wherein] a carrier density in a flat part of said second cladding layer having a current blocking structure [is] being at least $1 \times 10^{17} \text{ cm}^{-3}$ and no greater than $5 \times 10^{17} \text{ cm}^{-3}$.

Claim 3 has been amended as follows:

3. (Amended) A self-sustained pulsating laser diode according to claim 1, wherein said cladding [layer is] layers are made of a semiconductor that includes AlGaInP, and [the] said active layer is a semiconductor that includes [either or both] at least one of GaInP and AlGaInP.

Claim 4 has been amended as follows:

4. (Amended) A self-sustained pulsating laser diode according to claim 2, wherein said cladding [layer is] layers are made of a semiconductor that includes AlGaInP, and [the] said active layer is a semiconductor that includes [either or both] at least one of GaInP and AlGaInP.

Claim 9 has been amended as follows:

9. (Amended) A self-sustained pulsating laser diode [which] having a double-heterostructure [minimally] comprising:
 a first cladding layer of a first conductivity type;
 a multi-quantum well active layer; and
 a second cladding layer of a second conductivity type each being arranged on a semiconductor substrate of the first conductivity type, [wherein] the number of said quantum wells being at least 5; and
 [said] a layer thickness of a flat part of said second cladding layer having a

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current blocking structure [is] being at least 300nm; and [further wherein] an effective refractive index difference parallel to the [layer] layers (Δn) [is] being at least 7×10^{-4} and no greater than 3×10^{-3} .

Claim 10 has been amended as follows:

10. (Amended) A self-sustained pulsating laser diode according to claim 9, wherein said effective refractive index difference parallel to the [layer] layers (Δn) is around 1×10^{-3} .

Claim 11 has been amended as follows:

11. (Amended) A self-sustained pulsating laser diode according to claim 1, wherein said carrier density in said flat part of [the] said second cladding layer having a current blocking structure is less than $3 \times 10^{17} \text{ cm}^{-3}$.

Claim 12 has been amended as follows:

12. (Amended) A self-sustained pulsating laser diode according to claim 2, wherein said carrier density in said flat part of [the] said second cladding layer having a current blocking structure is less than $3 \times 10^{17} \text{ cm}^{-3}$.